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SOCIETY OF MOTION PICTURE ENGINEERS

Membership in the Society of Motion Picture Engineers is a marked distinction. Applications for membership are by invitation and endorsement. All checks should be made payable to the Society of Motion Picture Engineers.

All receipts are expended directly to promote the objects of the Society and the interests of its members. There are no salaries or emoluments of any kind.

The following are extracts from the By-Laws:

The objects of the Society are: The advancement in the theory and practice of motion picture engineering and the allied arts and sciences, the standardization of the mechanisms and practices employed therein, and the maintenance of a high professional standing among its members.

An Active Member is one who is actually engaged in designing, developing or manufacturing materials, mechanisms or processes used in this or allied arts; and an Associate Member is one who, though not eligible to membership in the active class, is interested directly in the art.

Any person of good character may be a member in any or all classes to which he is eligible.

Prospective members shall be proposed in writing by at least two members in good standing, and may be elected only by the unanimous vote of the Board of Governors.

All applications for membership or transfers in class shall be made on blank forms provided for the purpose, and shall be accompanied by the required fee.

The entrance fee (for both Active and Associate Members) shall be twenty-five dollars ($25.00). The annual dues for Active Members shall be ten dollars ($10.00), payable in advance on July 1st of each year. The annual dues for Associate Members shall be five dollars ($5.00), payable in advance on July 1st of each year.

CHAIRMAN'S ADDRESS

FELLOW ENGINEERS:

Those of you who missed attendance on the Washington meeting missed much. I know from the spirit shown at that meeting, and from the character of the gentlemen who attended, some of them coming from Chicago, some from New York, from Boston, and Cleveland, that this Society was formed with an honest intent to be of service to the industry at large; and that the officers and members alike intend to give largely of their time and energy for the promotion of the general good and without thought of financial reward; and as the engineer stands behind it all, we should feel due responsibility, while taking justifiable pride in our vocation.

The motion picture is making the whole world kin. It speaks the only universal language, understood by the illiterate of every tongue as easily as by the learned, and is rapidly tending toward tolerance in world thought. It not only shows us our distant neighbor, but also shows us ourselves as he sees us. It is making of the world one great family, and soon we will come to feel that we are a friend of the man over yonder, because we know him so well from seeing him in the picture so often.

Every new industry standardizes sooner or later, whether we will it or not. It is our duty, therefore, as engineers, to wisely direct this standardization, to secure best standards of equipment, quality, performance, nomenclature, and, unconsciously, perhaps, a code of ethics. It is entirely a practical and attainable ideal. But we should recognize our responsibility to fix standards with due regard for the interests of all concerned. It is an unselfish exchange of views which will make our gatherings interesting, and the discussions of individual investigation valuable.

Fortunately, one of the factors of our industry is already standard, the film. In this it is unique, for motion picture film is the only thing that is standard the world over. This it is that has given us the world as a selling field, and doubtless accounts very largely for the extraordinary growth of our business.

For that very reason our Society should represent more than just an association. Co-operation is all very well, but may be an entirely selfish bond, though this is sometimes temporarily necessary for self-preservation. But due regard for the rights of others reflects a gentleman in the mirror of our friend's countenance when we meet. Only under such unselfish circumstances can we ever expect to arrive at enduring standards in our art.

Let us, therefore, give of our best as we work at our craft. Let us each be truly American, known the world over as the man who, when's he's out for money doesn't mind work, when he's out for pleasure doesn't mind money, but when he is out for a principle doesn't mind either.

C. FRANCIS JENKINS.

PRECISION, THE DOMINANT FACTOR IN MOTION PICTURE MACHINES

W. B. WESCOTT
Boston, Mass.

MR. CHAIRMAN—GENTLEMEN:

We, in this body, will undoubtedly spend much time and thought on standards, and it seems to me that a cursory survey of the most important of these standards would be pertinent at this time—especially in their relation to each other, and the allowable departure from the standard; that is in the precision measure of the standard.

I think that you will agree that the final criterion of all motion picture standards is to be found *in the Picture on the Screen*. Hence, we may confine our efforts at standardization to those elements in which departures from a precise standard affect, directly or indirectly, our clear, steady picture on the screen. For instance, let us examine whether or not we shall consider for standardization the projector-magazine-reel spindle. Certainly;—because after all the evils of spindles, such as being out of true, too small, etc., are lightly passed over, and if I am not mistaken there are those of us who have something definite to say about this same reel-bearing-spindle; there may be seen on the screen the effects of a wobbling, heavy reel—the vertical vibration of the picture may be due in part to this,—the lateral vibration due to damage to the film edge by the unsteady reel,—scratches due to ripping when toward the last of the reel, there are sudden and violent changes in an already high angular velocity. Therefore, this spindle is worthy of a standard and the list of vital parts to be standardized is a long one.

We will find as we go down the list of elements that function toward the final picture, that *most* of them should conform to some standard—that there is *one* shape, size, position, relation or speed which results in *least action;* that is, produces the desired effect with satisfactory precision at a minimum expense of energy, material, space or wear.

But we will find that the precision measure of the standards will vary probably from element to element. For instance, our taking lenses should have at full aperture, as high a resolving power as possible, but not less than the lower limit of our standard; while with our present condenser systems, a more highly corrected lens than the usual projection objective will not show a marked improvement in definition on the screen. Then, for our taking lens, the standard must have much narrower limits than those permissible for our standard of projection objective.

And again, it is obvious that in the matter of projection machine aperture we have much greater latitude than we have in, say, the intermittent mechanism which positions, at this aperture, the image

to be projected. But inasmuch as these various standards will all come up for our consideration, each in its own good time, I need not enlarge further along this line.

Some of these standards will be found to be determined by custom, economy, or any of the many obvious considerations, while others will not be matters of choice at all, but will be derived from other standards.

Those standards which are matters of choice may be anything you please; such as three sprocket holes to the picture if you wish, and think you can make the innovation attractive to the majority. This is purely a matter of expediency. But the precision limits of these sprocket holes is not a matter of choice. Their size, shape and position in relation of the dividing line—choice again, but not the *amount* of *vibration* in the size, shape or position.

The variations in size may have a certain precision limit along one axis, and a precision limit of a whole order higher along the other—the length of the sprocket hole might vary by as much as plus or minus 1/1,000th of an inch; while a plus or minus variation of 1/10,000th of an inch in the width of the sprocket hole might produce a disturbing effect on the screen. And then again there are important and involved relationships which will prove to be of moment in the determination of precision limits. For instance, take the case of a mechanic's scale as a standard of linear measure, and even though it has suffered abuse it is still good enough as a standard with which to measure say, a few lengths of gas pipe—a low order of precision is perfectly satisfactory here; but if this same scale were to be used to measure the change in length of a short piece of film, with the change in grains of water per cubic foot of air, then it would be necessary to know at what temperature the scale was standard; and if used at any other temperature, its coefficient expansion, that corrections could be made to compensate for the scales departure from standard. It is important that this involved relationship should be borne in mind when considering the precision limits of standards.

But who then, is to determine these important precision limits and how? I do not mean the standards—some are still matters of choice—others are irrevocably fixed by custom, while still others will be found to be fixed by the requirements of their precision limits.

Gentlemen, there is one standard of transcendental importance, and when we have once defined it, then any of us can satisfy himself as to the precision limits of any other standard suggested, by the mere expedient or performing a few simple sums in arithmetic. But until this supreme standard is defined, no concordant precision relationship between such standards as there may be, can be hoped for.

Take the matter of projection speed—in any terms you like, such as pictures per second, feet per minute—intermittent R. P. M.—they may all be converted into the number of phase pictures presented to the eye in unit time. If there is no phase difference, that is no motion of the object photographed, then so far as the spec-

tator is concerned, the projection speed may be zero, for he sees a still, anyway.

A standard of projection speed, it is perfectly obvious, must depend, in general, on the average angular speed by the lens of subjects photographed; and this angular speed by the lens will depend on the length of exposure and on the standard of definition—circle of confusion—which, like the house that Jack built, will depend on one of the limits of our *supreme* standard—*The Picture on the Screen.*

Set a standard for the picture on the screen, and the precision limits of all your important standards are determined.

For some of the defining terms of our standard picture on the screen, it would seem necessary to consult individual opinion, but fortunately, for a few only.

From an extended statistical study it may be possible to ascertain to the satisfaction of the majority, the most important factor of all. *The position of the standard spectator in relation to the screen.* And our standard picture on the screen must be defined for the satisfaction of our standard spectator. For instance, it is more important that we know the angle subtended by the picture at the eye of the standard spectator, than that we know the size of the picture in feet, or even in projection aperture diameters, or the angle subtended by the picture at the projection objective; for whether or not lack of precision anywhere in the system will be apparent—not on the screen—but to the standard spectator, will depend in the main, on the angle of the spectator's view subtended by the picture on the screen. A moment's consideration will show that the same limits hold whatever the spectator's angular view of the screen picture is the same. This is to say that the same percentage change will produce the same effect where the picture is small and the spectator near, or the picture large and the spectator at a distance, so long as the picture occupies the same fraction of the spectator's field of view. And this will hold for any factor when the other factors are a constant.

Therefore, in order to build up a system of standards for the Motion Picture industry which shall be concordant, we must define and limit our standards, however they may be determined, in terms of precision measure—a percentage allowable variation. And to determine this *all-important precision measure* for any standard, we must refer to the picture on the screen as viewed by a standard spectator.

MOTION PICTURE FILM PERFORATION

DONALD J. BELL
Chicago, Ill.

My reference to Cine-machinery is intended to broadly cover all machinery used for the manufacture, assembling and projection of motion pictures, and I shall endeavor to briefly present my conclusions in reference to Standardization of perforations of Motion Picture Film.

For many years it has been my belief that there should be a concerted effort to bring about a meeting of designers and manufacturers of cinema apparatus so that this very important matter could be discussed by those who appreciate the far-reaching benefits that Standardization will bring to the motion picture industry.

Undoubtedly, all who are engaged in this line of endeavor have wished for a fixed standard to follow, but there has been no bringing together of designers and heads of the various departments of motion picture manufacturing establishments or those who direct the development and manufacture of projecting apparatus. Now, our genial friend—C. Francis Jenkins—has taken the initiative and by his invitation we are here to form the Society of Motion Picture Engineers.

I am sure we are all grateful for the opportunity that is now offered us and have come to New York City with a feeling of pleasure because we shall have the opportunity to lend our aid to the advancement of the Cinematographic Art. The invitation to join with you gentlemen as a charter member gives me great pleasure and I assure you that my humble efforts will be given happily and to the fullest extent of my understanding.

My present concern and greatest interest is—as you may infer from my previous remarks—STANDARDIZATION.

My first experience in this line of endeavor was employment as an operator—my employment beginning about May, 1897. The work had a great fascination for me. My ideas at first may have seemed to be only dreams to others, still I steadfastly maintained that it would not be long until motion pictures would cease to be a novelty, but were bound to become a greater factor in scientific research and educational effort, and to take a very important place among amusement enterprises. So, gentlemen, I decided to make this my life work and to gain an understanding of the subject that would win for me the respect of those engaged in the art of motion picture production.

As I gained experience and knowledge in the art of projection, my thoughts turned to the possibilities of improvement of the projecting apparatus I had in hand. My first efforts in designing showed me that it was a very difficult matter, indeed, to form a

projector so that perfectly steady control could be obtained when there were no standards to follow.

There seemed to be an endless variety of perforation gauges. Even the product of any certain maker of motion pictures showed a wide variation in distances between all centers, absolute uncertainty of spacing, and perforations of many varying forms.

Even one certain film subject would have all of the above characteristics. This made it necessary for all sprocket teeth to be machined so small that film of any or all variations would pass through the machine without damage.

As it was not practical to machine sprocket teeth or other means of control to closely fit into the sprocket holes of the film, it was found necessary to provide an extreme tension so that when the film came to the period of rest, it would remain in a fixed position, and on account of the variation of the position of the dividing line, it was necessary to provide means to bring the film in registration with the aperture as the various sections of the film came into position for projection. This means of adjustment was also necessary because the extreme tension on the film over the aperture caused a strain against the walls of the holes sufficient to cause tears, and a poorly made splice would often cause the film to leave the sprocket, which necessitated framing pictures many times during an exhibition.

These conditions still prevail, but I am happy to say in a far lesser degree than that of a few years ago.

There still is, however, a considerable variation in the products of various manufacturers, and I firmly believe that the first step toward standardization must be to establish what shall be the size and form and spacing of perforation.

In justice to the manufacturers of projecting apparatus, I must say that they now have provided a fixed standard, this being the diameter of the Intermittent Sprocket. Investigation shows this standard to be 15/16ths of an inch, and as this diameter appears to be in general use, it is well that this may be considered as a standard established and to be followed.

This standard gives a working basis on which we may determine what must be the distance between the centers of the perforations, both lineally and transversely, but before fixing these standard dimensions, we must consider the normal amount of shrinkage of film after development. We must consult the Laboratory Superintendents, and make thorough scientific tests to establish the normal amount of shrinkage of both length and width of film after being developed and dried. We then may establish standard lineal and transverse dimensions between centers.

The manufacturers of projectors do not appear to have established a standard distance between each series of sprocket teeth, but I believe they must look to the motion picture manufacturers to adopt a standard of perforation, so that they may have a guide

to follow in this particular, and for their guidance there must be a standard size and form of perforations.

The standard film perforating herein described was adopted only after long experience in building of motion picture machinery and the handling of film. As a suggested standard of measurements it departs from earlier standards only where it is necessary to do so in order to take into account the physical changes to which the film is subjected.

It is accepted as settled that the maximum shrinkage of motion picture film is .0937 inches per foot. Painstaking experiment warranted the conclusion—fully established by later experience—that a gauge length of 11.968 inches for 64 holes would insure the accuracy of perforation necessary to perfect results and at the same time make due allowance for shrinkage of the film.

The following computation shows why we adopt 11.968 inches instead of 12 inches as the standard for a perforation gauge measuring 64 holes:

Assuming the outside diameter of the sprocket wheel in all standard projecting machines to be 15/16 inches or .9375 inches, then;

The diameter of the sprocket being .9375 inches

The circumference of the sprocket is 2.94525 inches.

As standard motion picture film has an average thickness of .0065 inches the pitch diameter of the sprocket will be found to be .9375 inches plus .0065 inches, or .944 inches.

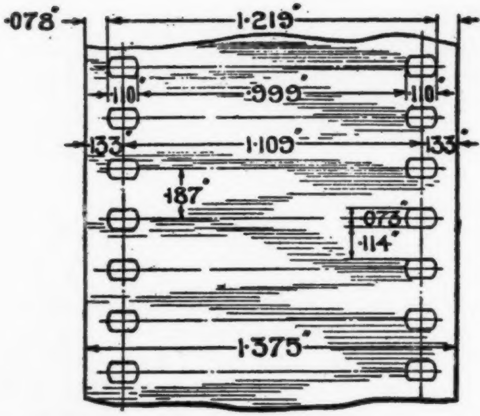
Pitch circumference is 3.1416 x .944 or 2.965704 inches. Circular pitch equal 2.965704 divided by 16 (the number of teeth to be found on the sprocket) or .1853—plus inches.

The standard perforating gauge being 11.968 inches for 64 holes and the maximum allowance for shrinkage of film being 3/32 inches or .0937 inches for 64 holes, therefore, 11.968 inches less .0937 inches or 11.8743 inches is the average length of shrunken film measuring 64 holes.

The pitch of the film or length per hole is 11.8743 inches divided by 64, or .18553 inches.

Pitch of sprocket, .1853 plus inches
Pitch of film, .1855 plus inches

The drawing shows the measurements by which the gauge is established; width of film over all 1.375 inches; width of film over all on perforation 1.219 inches; distance (width) center to center of perforations 1.109 inches; distance (width) inside to inside of perforations .999 inch; width of perforation .110 inch; distance (width) center of perforation to margin of film .133 inch; distance (width) outside of perforation to margin of film .078 inch; length of perforation .073 inch; distance (length) between perforations .114 inch; distance (length) center to center of perforations .187 inch.



With perforation, sprocket, dividing line and other standards effected, then within a reasonable time the manufacturers of projecting apparatus may conform their means of control to closely fit the standardized perforations, and I am sure the whole industry will profit to an almost unbelievable extent. Most certainly strong tension to effect registration may be eliminated and this will insure against damage of film and perfect projection may be obtained.

We may all be proud of the achievements of the American Manufacturers of Motion Pictures and apparatus for their making and projection.

Let us all join together and earnestly endeavor to set a standard of photographic and mechanical excellence that will be the standard of the world.

CONDENSERS, THEIR CONTOUR, SIZE, LOCATION AND SUPPORT

C. FRANCIS JENKINS
Washington, D. C.

Surprisingly little literature has been written on the subject of condensing lenses, and none at all with regard to their use in motion picture projecting machines. Investigators outside our own art have so far failed to observe that the problem is not the same in a motion picture projecting machine that it is in a stereopticon lantern, a difference resulting from the necessity for the use of a shutter with the motion picture projector.

I shall confine my remarks practically wholly to the problems of the illumination of the picture aperture of a motion picture projecting machine, and its result on the canvas, rather than to the subject, generally.

Condensing lenses are employed because it is practically impossible to illuminate the film directly. When we get a cold light it may perhaps be feasible, though this is debatable. But for the present, condenser lenses, for gathering the diverging rays of the luminant and converging them on the picture aperture, continue to be used.

Two lenses are usually employed in combination for the reason that to get the same gathering power with the same convergence in a single lens there would be too great a loss of light by reflection from the curved surfaces. So lantern makers usually take two plano-convex lenses and mount them with the curved surfaces together, which puts a flat side next the light source.

As a simple but rather interesting experiment showing the loss of light by reflection, hold up your next glass of water and try to look upward through the surface of the water at about 45° angle. You will not be able to see anything above the water until it actually touches the surface.

This total reflection phenomena is usefully employed in many ways, e. g., in engraving plants to reverse the picture for etching; in binoculars to give a large field and long-range-telescope in short, compact form; in periscopes to see without being seen; in the Graphoscope for mechanical simplicity and convenient operation.

But this same reflection when from the surface of a single condenser, is a very decided loss. For this reason it is usual to employ two lenses in a condenser system. The first lens, the lens next the source of light, an electric arc usually, is popularly described as gathering the diverging rays and paralleling them, the second lens then converging them on the aperture plate. Lenses of 6½ and 7½-inch focus are usually employed for short projection distances, with the arc lamp 2½ to 3 inches from the surface of the arc lens.

To parallel the light rays with these two lenses the arc should theoretically be 6½ inches from the lens. But this is not best, for at the closer position more than four times as much light at the aperture results. If the rays could be paralleled by the first lens, the arc lens, then the converging lens might be any distance away. Because the arc lens cannot do this, the second lens, the converging lens, is brought up close to the arc lens in order to catch as large a portion of the rays as possible and concentrate them on the picture aperture.

Authorities on lenses have heretofore recommended that these converging light rays cross in the center of the projecting lens, but their conclusions have been based upon the old lantern slide assembly which had the pictures just in front of the converging lens, and did not employ a shutter at all. Their recommendations are not, therefore, wholly applicable, nor is the arrangement proposed for the lantern the best for motion picture projecting machines.

It might be nearer right if we could get lenses made so that the shutter could cut across the rays at the narrowest part, that is, at the diaphragm location in the lens. But this is not practical, because, among other things, a variety of focal lengths of projecting lenses are required for different projection distances, or "throw" as the operator usually terms it. The preferable arrangement is, therefore, to put the shutter in front of the lens, and then to have the rays of light cross at that point.

The principal reason for having the shutter at the narrowest part of the projected light-beam is that the obscuring blade may be as narrow as possible, so that when the other two blades, the flicker blades, are added they may each approximate the width of the obscuring blade and yet give a fifty-fifty ratio of light to darkness, which is the ideal arrangement for a flickerless picture today.

To readily determine where the light beam is narrowest is not alwasy easy, for the light cone is not readily discernible. If, however, a card is passed vertically through the light just in front of the lens, a shadow will cross the screen, say, from top to bottom; with the card farther out the shadow will cross from bottom to top; but at a median position the passing of the card causes a shadow to cover the whole screen at once. That is the proper location for the shutter. One should remember, however, that a shutter that is just right, that is, most efficient, at this point will show halation or streamers, both above and below the letters of a title, if the arc is moved very much either toward or away from the condensers.

There are other factors also which have a bearing on the location of the various elements of the projection system. For example, a longer projection for the same size picture requires a projection lens of longer back focus. This again requires a longer cone of light from the converging lens. This lens must, therefore, be changed for one having less curvature. But when this is done the light spot on the aperture is too large, and the lamp house must be moved back. This draws the apex of the light cone back within the projecting lens barrel, so that another change is required. By repeated trials one would

probably find the proper lens and best lamp-house position, but the easier plan is to advance the arc a little when an approximately correct lens and lamp-house position is found, and this is usually done.

When the lamp-house is moved back for the long "throw" it is not unusual to change the arc lens to a 7½ lens, making the combination two 7½ lenses. The resultant light loss is considerable, however, 50 per cent, perhaps. This loss of light has given rise to an erroneous idea that the longer throw requires a correspondingly greater amount of current for a given size screen. Another plan is to let the 6½ arc lens alone, and substitute an 8½ lens for the 7½ converging lens. This will give the same amount of light on the same screen at the longer distance, without increasing the current consumption. A 6½-inch and 8½-inch lens combination has practically the same equivalent focus as two 7½" lenses, though the reciprocals are not exactly identical in both cases. However, the distortion of poor lenses sometimes prevent getting an even, white-lighted screen.

This brings us very naturally to the consideration of a better lens arrangement for the lens next the arc, for, if this can be made a fixed factor, then the matter of adjustment for different lengths of throw is simplified.

Taking up the consideration of the arc and the theoretically best adjacent lens-surface it is at once apparent that if a curved surface could be employed, the same safe distance might be maintained between the arc and the lens at its center, while the outer edge of the lens, by reason of its enveloping curvature, would gather very much more light. But to make a single lens of this conformation having the same 6½-inch focal length as the plano-convex usually employed gives the opposite or convex surface of the lens a disastrous curvature. A better plan is, not to attempt the total light refraction with the one lens, but set another close thereto having such a curvature that the sum of the two will give the focus desired. A lens of — 1½ and + 6½ (dioptric measurement), say 8" focus, in combination with a 10-inch, either bi-convex or a plano-convex, is about correct for a three-inch arc location and is an ideal arrangement, but unfortunately, it is only ideal. A meniscus of six-inch focus would have to be about a + 7 which, obviously, is not practical. The use of a — 1½ and + 5½ lens, about 10" focus, in combination with either a bi-convex or plano-convex lens of 10-inch focus, is good, being approximately the equivalent of a 5" lens. This combination used with a 7½, 8 or 8½-inch plano-convex, seems to make a very satisfactory three-lens meniscus set.

There is still another factor to be taken into consideration—namely, the liability of condenser breakage. But, as has been explained, if the arc can be kept close to the lens very much less current is required for the same screen illumination. And right here a Kelvin law helps us very materially, i. e., "the light of an arc lamp increases directly as the increase in current, while the heat increases as the square." Obviously, therefore, if we can employ such an arrangement as will require but half as much current as another we get but one-fourth as much heat.

But at best the heat is such that the condenser gets very hot though the heat of itself alone does not crack lenses. In actual practice I have found that if the arc lens is held in a non-conductive ring it will never break no matter how hot it gets. Lenses crack because of unequal stress in the glass, and this comes about because something has carried away heat from a limited area and not from the whole mass evenly. Thus, if one should touch a very hot lens with a piece of metal, say, a screw driver, the lens will crack, because the metal being a better conductor of heat than the glass robs the glass of its heat at the point of contact and the equilibrium of stress is disturbed and the glass cracks. I have had the glass crack across between my thumb and finger when I attempted to pick up a hot lens by its edge (without knowing before that it was hot). If the lens is heated evenly and remains so, that is, is not robbed of any part of its heat by a conducting or convecting medium it will never break. A complete understanding of this phenomena and its proper recognition by the operator, would enable him to get a much more brilliant screen picture with much less current consumption.

It is exactly the same with many other improvements which might be attempted if we had graduate engineer operators to handle our machines. So the best we can do is to make a compromise machine and wait until the public grows up to our ideals. In this category is an adjustible shutter; and the three-lens condenser system I've just been talking about; and, to come closer home, a multiple-negative carbon arc with its single unshadowed crater in the exact axis of the optical system, an ideal arrangement which we had to give up because we couldn't take the time to teach each operator where such a lamp was installed, if, indeed, he were teachable.

Much of what is here explained could be calculated with exactness and applied by rule if the source of light were an infinitely small point, and condensers were as carefully ground and annealed as projection lenses, which, however, isn't the case. Also the condensers and light source area have a definite bearing on the sharpness and brilliance of the screen picture aside from the question of illumination. The optical system of motion picture machines is a makeshift, and I hope that some of us will undertake a systematic investigation of it looking to a more definite knowledge and resultant improvement.

In conducting experiment with motion picture machines it is desirable, on occasions, to take the heat out of the light so that the light may shine on the film continuously for an indefinite time without igniting or puckering the film. The usual plan is a tank of water, located between the condensers and the picture aperture, through which the light must pass. This is a help, perhaps, but not wholly effective. Alum is sometimes added to the water, but, so far as my experiments go, adds nothing to its heat absorbing property.

After repeated trials and finding that the water cell did not furnish the required protection, I set about to find out what would, and developed some surprises. Our first surprise was the discovery that ice water was less effective than warm water. Next I found that a

plurality of thin glass plates, spaced apart, served the purpose admirably. The only trouble encountered was the breaking of the plates through which the light first passed. This, because the plates were heated in the region of the light spot faster than the glass could conduct it to the parts of the plate lying outside the path of the light.

To overcome this difficulty, a water cell was made into which glass plates were put, the water serving the purpose of equalizing the heat over the whole surface of each plate. No more breakage was then encountered. In order to dispell any doubt in your mind about the true reason for the results, I might add that after the cell was filled with water, but before the spaced glass plates were put in, the film ignited in from 32 to 35 seconds, but that after eight or ten plates were put in, the film was not ignited, or even puckered, after repeated tests of 25 to 30 minutes duration. This device cuts off some light—I have not yet had time to measure the loss—but a 50 per cent loss is permissible and still have as much screen illumination as results from the running of the machine without it but with the usual 50-50 shutter.

In this connection it may not be amiss to caution any of you who may wish to construct such a cell, that the cell must be not less than about three times the width of the beam of light. I am not yet ready to say just why a narrow cell is not as good as a wide one in preventing the ignition of the film, and so will reserve a positive statement until from repeated experiments I can be certain of it.

Another thing which is interesting is that the same number of plates in surface contact with each other will not prevent ignition. A mica cell with spaced sheets is also effective, but the color of the mica and the flimsy, thin sheets are objectionable.

Another observed phenomena which gives further evidence of the complexity of the projected light is that:—

There is a point between the condensers and the aperture plate at which a pencil, screw driver or other slender object held in the cone of light does not cast a shadow on the screen.

This seems incredible, but comes about probably because the heat rays, the light rays, and the color rays, which had, therefore, been more or less separated, so criss-cross and mix-up at this point that there are not enough directed rays to carry a defined image to the screen.

Further investigation of the light in this region is being made and will perhaps be presented in another paper following this primer presentation of the subject of condensers in motion picture projecting machines.

In concluding, let me encourage you to original research, for the field is full of opportunity for profitable investigation. Stop a moment and think of it; no material change has been made in the mechanism, and no change whatever in the principle involved in projecting machines since the first projecting machine was deposited in the U. S. National Museum twenty odd years ago. It had the

same arc lamp used today, the same two condenser lenses, the same aperture with tension plate, the same upper and lower sprockets, the same left-handed construction, and the same noise of an intermittently-moved film. Here is abundant opportunity for original research work and improvement.

Nor have facts relating to lamp-house setting, lamp location, condensers, or other similar factors, been tabulated,—not even the averages of the thousands of machines in use today. I think it should be done.

A condenser lens which I believe would be worth while to experiment with is the corrugated principle employed in light-house lenses. I hope that at our next meeting some one will be ready to read us a paper on lenses of this character.